SUBORBITAL AND SPECIAL ORBITAL PROJECTS DIRECTORATE

ARGOS
Interface Control Document for the ULDB/Tiger Mission

Effective January 2001

Signature on file

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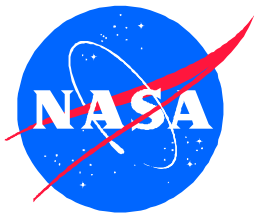

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ARGOS ICD 0007

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes
Baseline	05/1999	Initial release
Revision 1.0	07/2000	Affects entire document
Revision 1.1	09/2000	Recodification

Contents

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Flight Software ARGOS
Interface Control Document
for the ULDB/Tiger Mission

1.0 Operations Description

The ARGOS communication link serves as a global data downlink transmission only device. The ULDB flight computer interfaces to a platform-transmitting terminal (PTT) via an asynchronous RS232 connection. The ARGOS PTT manufacturer is Telonics and the model number used in reference is ST-13. Complete ST-13 interface information is provided in the 'User Manual for the Telonics ST-13 Asynchronous Serial Interface'. The ARGOS Service Network operates the ARGOS satellite network in a random access mode. Complete interface information for ARGOS Service Network is provided in the ARGOS 'User Manual'.

1.1 Purpose

The Purpose of this document is to provide a detailed description of the electronic interface between the Ultra Long Duration Balloon (ULDB) flight computer and the ARGOS ST-13 platform-transmitting terminal (PTT).

1.2 Scope

This Interface Control Document (ICD) defines and controls the communications, format, protocol, messages, electrical and mechanical characteristics of the interface between the ULDB flight computer and the ARGOS ST-13 PTT.

1.3 Time Frame

This ICD shall be in effect from the date of approval by the Balloon Program Office, the Real Time Software Engineering Branch, and when all applicable signatures are obtained.

2.0 Mechanical Interface

2.1 Dimensions

9.225 inches x 2.75" x 1.09". Reference Figure XXX.

2.2 Mass

<200g

2.3 Mounting

Both ST-13 PTTs will be mounted in a 12" x 3" x 2.2" NEMA enclosure. (NEWARK P/N 95F2593)

2.4 Connection

Power: DB25
RF Out: BNC Female
Interface: RS232

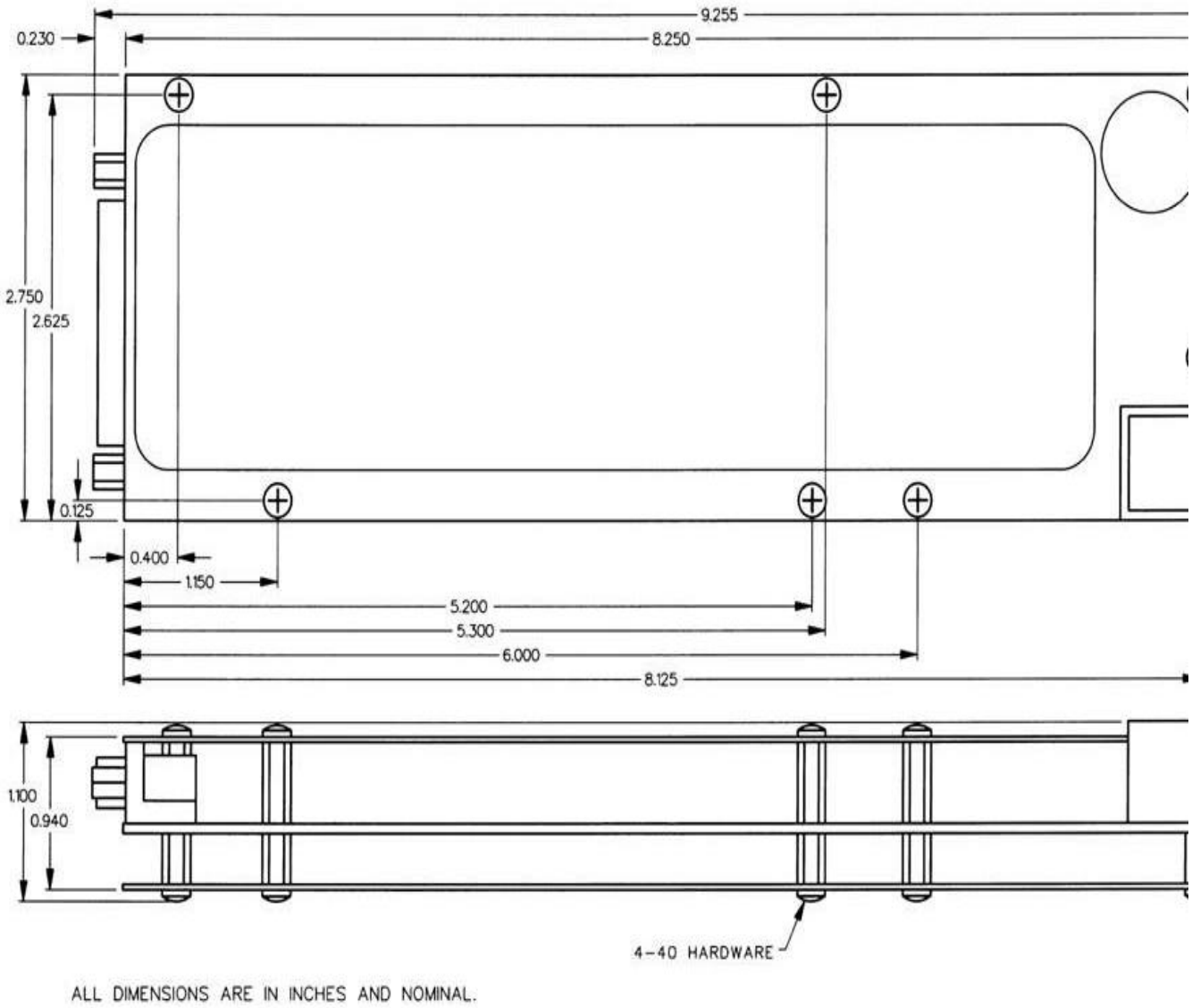

Figure 1. ST-13 Mechanical Layout

3.0 Electrical Interface

3.1 Connectors and Pin Assignments

The hardware connection for the ARGOS communication link is via an asynchronous RS-232 link from the ULDB flight computer to the Telonics ST-13. Below is a pinout of the Telonics ST-13 DB-25 female connector.

Pin 1: Async Wake-up Signal
RS-232: This line is pulled to ground through a 30K Ohm resistor. The idle state of this line is low (0 to –15V). Pulling this line high (+5 to +15V) will cause a wake-up interrupt in the ST-13.

Pin 2: TXD: Used to transmit data to the ST-13

RS-232: an RS-232 line driver drives this line. When the ST-13 is awake and communicating with the host, the idle state of this line is low (-5 to –15V). Start bits and Zero bits are transmitted with this line in the high state (+5V to +15V). One bits are transmitted with this line in the low state (-5 to –15V). Note that when the ST-13 is not communicating with the host (i.e. between commands), the RS-232 driver chip is powered down to save battery power. This causes the TXD pin to be pulled toward 0V. The host system must be aware of this and disable its receiver during this time.

Pin 13: Common ground for transmit, receive and wake-up signals.

Pin 14: RXD: Used by the ST-13 to receive data from the host.
This line is connected to a RS-232 line receiver, which has an internal 5K-Ohm resistor to ground. The host should hold this line low (-5 to –15V) for the idle state and for one bits. This line should be driven high (+5 to +15V) for start bits and zero bits.

Pin 22: CR: +5 V source used in some application requiring pull-ups.

Pin 11, 23: - Battery: Negative Power Applied

Pin 12, 24: + Battery: Positive Power Applied

Pin 25: Digital Ground

ST-13 Electrical Interface

Figure 4 illustrates the termination of the serial I/O pins internal to the ST-13 for the RS-232 interface. Each pin is RF filtered and the wake-up pin has 30K Ohms of resistance to ground. The TXD and RXD pins come directly from an RS-232 driver/receiver chip. Note that this chip is powered on when a wake-up signal is received, and powered off after reception of the complete command from the host. The flight computers TX and RX lines should be connected to the RXD and TXD lines of the Argos Transmitter respectively. Grounds should be shared accordingly. Pinout descriptions are described under section 3.4 Hardware Configuration.

3.2 Wiring

RFI Shielding

Note: Due to open frame design of the ST-13, both transmitters will be mounted in the aluminum box to minimize RFI.

4.0 Power and Thermal Interface

4.1 Operating Voltages

+7.0 Vdc to +14.0 Vdc

4.2 Power Consumption

1.3 W/525 mA @ +14Vdc during transmission into 50 Ohm load
0.5W/350mA @ +7Vdc during transmission into 50 Ohm load

4.3 Power Dissipation

6W (.525A)(14VDC)-(1.3W RF OUT)=6W Dissipation

4.4 Operating and Survival Temperature Range

Operating Range -40deg. C to +60deg.C
Storage –60deg C to +80deg.C

4.5 Thermal Considerations

No special thermal enclosures or insulation are needed.

5.0 Data and Command Interface

5.1 Data Interface

ST-13 Software Configuration

This section details the factory set features available on the Telonics ST-13 transmitter.

5.1.1 ID Codes

The ARGOS satellite network sorts data received by assigning unique ID codes. The ULDB mission makes use of each ID code to maximize housekeeping data and structure data in accordance with each ID. Eight ID codes have been programmed into the PTT at the factory with a data transmission capability of 32bytes/ID, and have assigned the ULDB mission 16 unique IDs. Each ST-13 has a factory setting of 8 of these assigned ID codes. A total of two ST-13s, one for each flight computer, shall be active at all times. The ID code assignments are listed below:

ID#	HEX	DECIMAL	TRANSMITTER #
1	92010	9344	1
2	93F09	9468	1
3	9457C	9493	1
4	959E2	9575	1
5	9741E	9680	1
6	97A51	9705	1
7	97B4E	9709	1
8	98BD8	9775	1
9	92043	9345	2
10	93F5A	9469	2
11	94589	9494	2

12	95A36	9576	2
13	9744D	9681	2
14	97AA4	9706	2
15	97BBB	9710	2
16	98C23	9776	2

5.1.2 Repetition Rate

Each ID transmission of data (up to 32 bytes) shall be repeated at a known repetition rate. The ULDB program has assigned two different repetition rates for each transmitter since ULDB uses two ARGOS ST-13 transmitters, one for each flight computer. Each ARGOS transmitters shall be transmitting simultaneously at the same frequency, and therefore will require a means to prevent data from one ARGOS ST-13 ID from overlapping onto the other. Currently, the repetition rates are set for 59 seconds on one ARGOS ST-13 transmitter and 61 seconds on the other.

Each flight computer should space out ID transmissions evenly and not repeat any single ID transmission any sooner than the specified repetition rate. For example: 8IDs/transmitter at a repetition rate of 61 seconds yields 7.625 seconds/ID. This would mean that the flight computer would have 7.625 seconds to transmit up to 32 bytes of data on one ID before the next data set on another ID should be sent. It is conceivable that all 8 IDs could be sent out one after the other, however it is desirable to not burden the flight computer processor any more than necessary. The transmitter requires a minimum of 1 second for a complete data transmission of one ID and therefore sets the minimum amount of time required for each ID transmission.

5.1.3 Failsafe Mode

The Failsafe mode allows users to know when the host has stopped communications with the transmitter. The Failsafe mode will become active once it is enabled, the host has not successfully commanded the ST-13 longer than the factory set time out interval, and the unit is not operating in the “automatic repeat transmission” mode. The Failsafe mode is factory set to be enabled upon powering the unit up and can be toggled on or off by the host

5.1.4 Failsafe IDs

Each transmitter for the ULDB mission contains separate Failsafe mode IDs that identify a “Failsafe” mode condition. Below is a table of these IDs.

TRANSMITTER #	DECIMAL	HEX
1	9305	9167C
2	9306	91689

5.1.5 Failsafe Repetition Rate

The Failsafe repetition rate is the interval at which a Failsafe ID and message will be repeated. The factory setting for both ST-13 units is 60 seconds.

5.1.6 Failsafe Timeout Interval

The Failsafe timeout interval is the amount of time elapsed with no host communications with the ST-13. The factory setting for both units is 60 minutes.

5.1.7 Failsafe Message Length

The Failsafe message length allows users to annotate a unique message of up to 28 bytes for all Failsafe mode transmissions. The first four bytes of all Failsafe messages always contain an error count and up to four of the most recent error codes. The factory setting chosen for the Failsafe message length on both units is 0 bytes. The ID will be used to identify this mode with no other message format required.

5.1.8 Failsafe Duty Cycle

The Failsafe duty cycle allows for periods of Failsafe mode on and off time. The factory setting chosen for the Failsafe mode duty cycle is continuous. The host is required to re-establish communications with the ST-13 to disable Failsafe mode transmissions. The ST-13 can be powered off if communications cannot be re-established.

5.1.9 Transmit Error Counts Mode

The "Transmit Error Counts" allow the user to track any transmission errors. The first 4 bytes of each transmitted message contain the error count plus the most recent error codes. The user can enable this mode as on or off.

Message Formats

Three distinct message formats are identified for transmission: "Failsafe" mode, "Transmit Error Counts" mode, and a message format without "Transmit Error Counts" mode. Figures 1--3 identify each of these message formats. These formats are representative of the transmitted format and not the received formats returned to the GSE from service ARGOS. The received formats are explained in the ARGOS SERVICE MANUAL 1.0, January 1996, Chapter 4, Page 78.

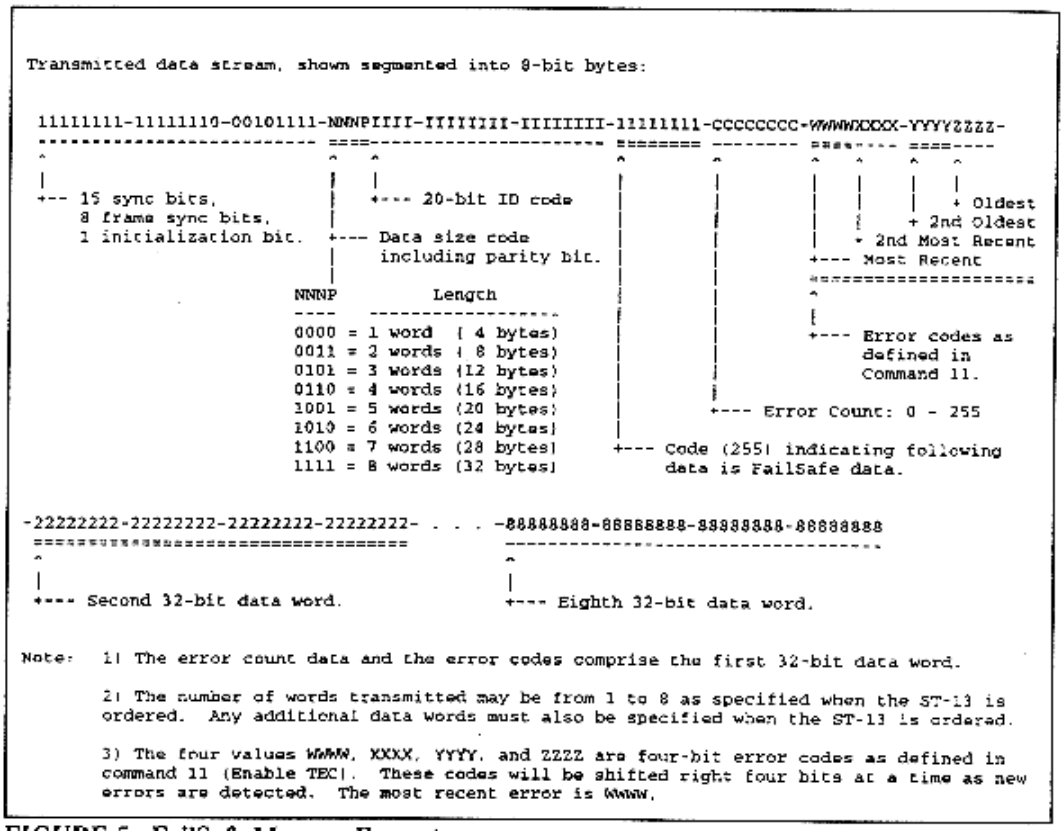

Figure 1. Failsafe Mode Transmission Format

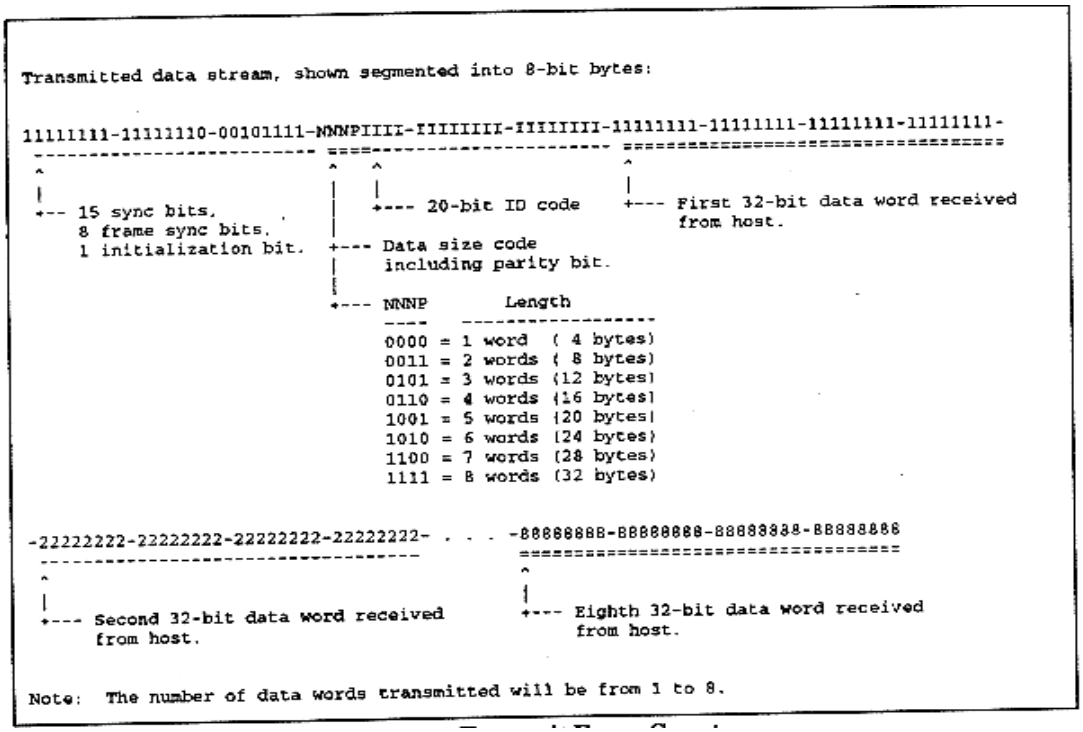

Figure 2. Message Format with Transmit Error Counts

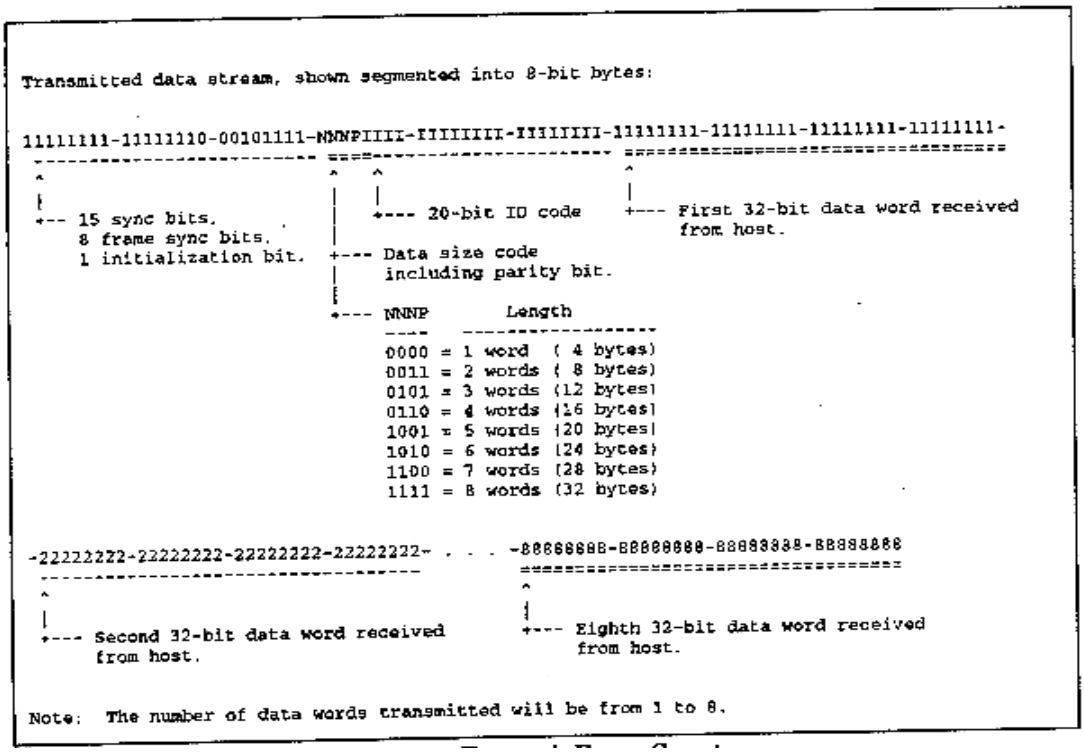

Figure 3. Message Format without Transmit Error Count

6.0 Flight Software Interface

Protocol

The serial communication protocol for the Telonics ST-13 is the following:

- Asynchronous serial utilizing standard NRZ format.
- One start bit, eight data bits, one stop bit, no parity.
- Baud Rate = 2400
- Data is transmitted least significant bit first.

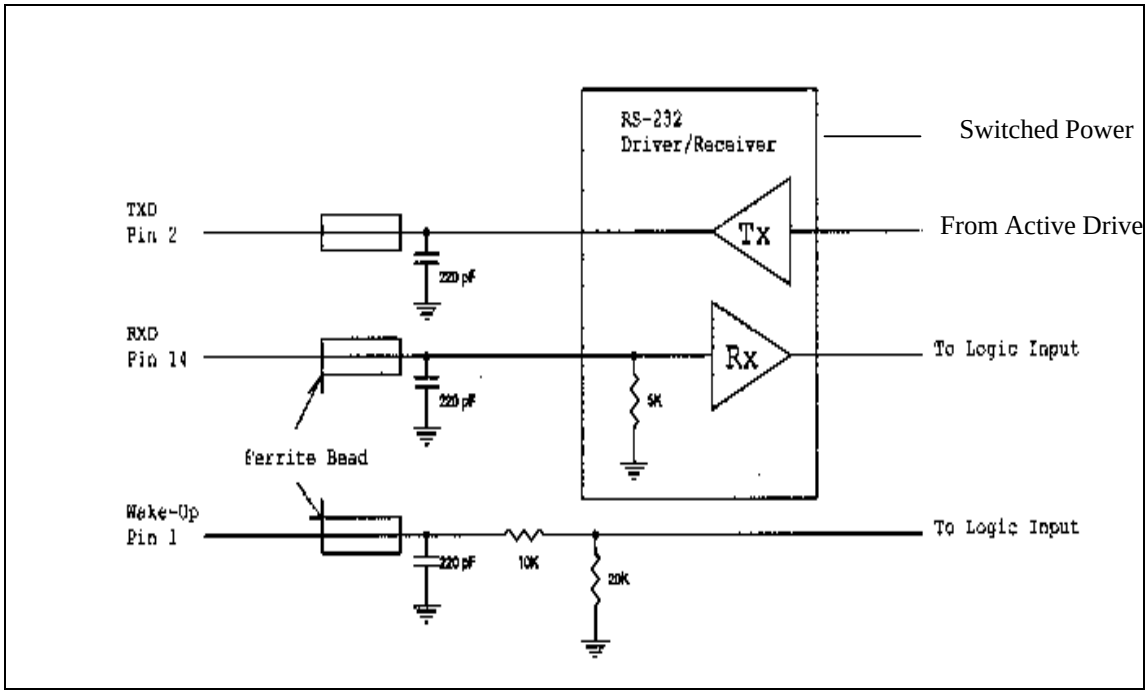

Figure 4. Serial I/O, RS-232 Termination

6.1 Commanding

Commanding the ST-13 is performed by the bi-directional RS232 connection. All commands received by the ST-13 are acknowledged by an ACK while those commands not recognized are acknowledged by a NAK. Use of the acknowledgment commands is accomplished by connecting the ST-13's TXD line to the host UART's RXD pin.

Commands sent by the flight computer to the ARGOS transmitter (ST-13) consist of a command byte specifying the function to be performed and an ID code that associates the data being transmitted. Specifying an ID code is accomplished by passing a number between 0 and 7 that acts as an internal lookup table of stored ID codes in the ST-13.

6.1.1 Command Data Format

The host must send the ST-13 command bytes and data bytes in the format of 8-bit binary. The host UART (flight computer) must configure to send 8-bit binary with no parity.

6.1.2 Command Initiation

Each command is initiated by the host sending a momentary active high signal for an RS232 connection that last for 25-100 milli-seconds on the wake-up line of the ST-13. The host (flight computer) must wait for 1 milli-second after the wake-up signal has been returned to its idle state before serial transmission of the command byte can occur. The host can then transmit the command byte after the delay along with any other appropriate data bytes. The ST-13 will respond with an ACK if it acknowledges a valid command or NAK for invalid commands after it receives the command and data from the host. The ST-13 will enter a sleep mode after sending its response and must be re-awakened before *any* other commands can be transmitted from the host.

A delay of 100 milli-seconds is required between the last byte received by the ST-13 and the next wake-up pulse for the following command. Command execution requires a time delay dependent upon the command. The wake-up pulse for the next command should be delayed until after the last byte of the current command is transferred. This ensures that the current command completes execution and that the next command has sufficient time to be received. Commands not requiring transmission of data typically require a 100 millisecond delay before the next command is issued. However, those commands that do require initiation of a transmission will require up to 3 seconds.

6.1.3 ST-13 Acknowledgment

The ST-13 should respond with every host command sent to it with either ACK (00000110) or NAK (00010101). However, the ST-13 should be re-awakened and the command retransmitted if after 3 seconds the host has not received an acknowledgment. If 5 attempts to transmit the same host command have failed, a serious interface problem exits (such as moisture penetration). The host should abort any further attempts and try later to send the command in hopes that the problem has corrected itself.

6.1.4 ST-13 Time Out

The ST-13 uses a “watch dog” timer once it receives a wake-up signal. If within 2 seconds the ST-13 does NOT receive a command byte and any required data bytes, a series of events begin:

- A time out situation is declared.
- The read operation by the ST-13 is aborted.
- The ST-13’s internal error counters are incremented.
- A NAK is sent to the host.
- The ST-13’s RS232 driver/receiver chip is powered down.
- The ST-13 goes back to sleep.

6.1.5 Commands

Eight bit binary commands define how the ST-13 is to perform. Below is a table listing of the commands available and a description.

6.1.6 Transmit and Store Commands

The Transmit and Store commands describe how the ST-13 stores data in its buffers, transmits data, and combines both store and transmit capabilities.

- **Store Data 1**

Format: 00010xxx

The Store Data 1 commands the ST-13 to store 8-bit binary data to buffer number 1 in the ST-13, but does not transmit. The "xxx" value varies from 0 (000) to 7 (111) and refers to the index of 8 possible ARGOS ID codes programmed by the factory in an internal look up table of the ST-13. This allows the host's data to be identified with a particular ARGOS ID when the data is transmitted.

The amount of data bytes/ID is 32. The ST-13 error counter is incremented when the host does not send enough data bytes. The operation will then be aborted and buffer number 1 is marked as containing no data. The Auto-Repeat function will be canceled if active to eliminate any invalid data. If the host sends more data than that required by the ARGOS ID code factory setting, the excess bytes are ignored and the initial amount is placed in buffer #1 while no error code is generated. The table below details how the ST-13 index corresponds to the command.

Binary CMD	Hex CMD	Decimal CMD	ID Index
00010000	$10	16	1
00010001	$11	17	2
00010010	$12	18	3
00010011	$13	19	4
00010100	$14	20	5
00010101	$15	21	6
00010110	$16	22	7
00010111	$17	23	8

- **Store Data 2**

Format: 00100xxx

The Store Data 2 command places data bytes into buffer #2 of the ST-13, but does not transmit. The same conditions exist for this command as did the Store Data 1 command.

- **Store and Transmit 1**

Format: 00110xxx

The Store and Transmit 1 command stores data in buffer #1 and immediately transmits the data. The time between command initiation and transmission completion can be up to 8 seconds. No commands must be initiated for buffer #1 while this command is active to ensure transmission of buffer #1 as complete.

- **Store and Transmit 2**

Format: 01000xxx

The Store and Transmit 2 command is performed in the same manner as the Store and Transmit 2 command except data is stored in buffer #2 before transmission.

- **Transmit 1**

Format: 01010xxx

The Transmit 1 command transmits previously stored data from buffer #1. No data follows this command. The "xxx" value corresponds to the index of 8 different (0-7) ARGOS ID codes. The command operation will be aborted and the error counter incremented if the amount of data stored in buffer #1 is different than the factory programmed message length for that ARGOS ID. The ULDB mission uses 32 bytes/ID for all ARGOS ID codes. A total of 8 seconds is required to complete the command initiation to completion of transmission. No other commands should be initiated during this time that involve buffer #1 to ensure all of buffer #1 contents is transmitted.

- **Transmit 2**

Format: 01100xxx

The Transmit 2 command transmits previously stored data from buffer #2. The same conditions exist for this command as the Transmit 1 command except the Transmit 2 command uses buffer #2 to transmit data.

- **Auto-Repeat**

Format: 0110zyx

The Auto-Repeat command allows RF transmissions to be repeated at default or programmable intervals automatically. This command uses 1 to 3 bytes depending upon if the ST-13 default values are used for repetition rate and repetition count. The Auto-Repeat command will consist of 1 byte if bit y = 1. Otherwise, the Auto-Repeat command will consist of 3 bytes whereby bit y = 0 and the host supplies the command, repetition rate, and the repetition count. The least significant bit (LSB) of the first command byte, x, specifies which buffer to extract data from. Buffer #1 will be repeated if x = 0 while buffer #2 will be repeated if x = 1. Buffer #1 and buffer #2 will be alternately repeated if bit z = 1. The command byte LSB dictates which buffer to begin alternating if bit z = 1.

The second command byte (if used) identifies the repetition rate in seconds added to a 42-second base. The minimum repetition rate of 0 seconds indicates a total repetition rate of 42 seconds while the maximum repetition rate of 255 indicates data to be repeated at 297 (255+42) second intervals. The final command (if used) identifies the number of repetitions (1 to 255). This final command requires the buffer to be preloaded using the Store Data 1 or Store Data 2 command. An NAK will be sent to the host and the system error counter incremented if the specified buffer is not previously set up.

The repetition rate and repetition count normally supplied in bytes 2 and 3 are stored as default values in the ROM of the ST-13. The default total repetition

rate and repetition count for both ST-13s on the ULDB mission are 59 (42+17) & 61 (42+19) seconds for transmitter #1 & #2 and a repetition count of 1 for both transmitters. The factory sets the default settings at the time of order.

- **Cancel Auto-Repeat**

Format: 10000000

The Cancel Auto-Repeat command terminates an Auto-Repeat command before it completes all of its programmed iterations. The Cancel Auto-Repeat command is required to cancel any Auto-Repeat operations before loading new data into the buffers.

- **Null Command**

Format: 10110000

The Null command does not cause a transmission and should be used by the host to let the ST-13 know the host is alive. Otherwise, the ST-13 will enter a Failsafe mode. The ST-13 responds by sending an ACK to the host letting the host know everything is OK with serial interface.

- **Disable TEC**

Format: 11000000

The Disable TEC command disables the "Transmit Error Counts" mode. Details of the TEC mode are discussed under the Enable TEC command.

- **Enable TEC**

Format: 11010000

The Enable TEC command enables the "Transmit Error Counts" mode. The "Error Count Marker" (1byte), the "Error Count" (1byte), and the four most recent error codes (2-bytes) are enabled into the ARGOS data stream. The TEC mode message format is presented in Figure 2. Below is a listing of the 4-bit error codes and their definitions.

BINARY ERROR CODE	DESCRIPTION
0000	No error (OK)
0001	Failsafe Timeout
0010	Illegal command from host
0011	ARGOS ID Code index not legal. The index value is greater than the number of ID Codes stored in the ST-13.
0100	Size of data residing in requested buffer is inconsistent with the specified ARGOS ID.
0101	Host took more than 2 seconds to complete transmitting data following "wake-up" signal to ST-13.
0110	ST-13 UART detected overrun
0111	ST-13 UART detected line noise
1000	ST-13 UART detected a framing error (stop bit not in position)
1001	Auto Repeat – Buffer requested by host not valid (does no contain

	any data)
1010	Auto Repeat -- Zero transmission iterations specified by host

- **Disable Failsafe**

Format: 11100000

The Disable Failsafe command disables the Failsafe mode. This command requires the 16 bytes of hexadecimal qualification data following the binary command. The qualification data is the following: AA, AA, AA, AA, AA, AA, AA, AA, AA, AA, AA, AA, AA, AA, AA, AA. This command resets the internal counter, which controls the Failsafe duty cycle.

- **Enable Failsafe**

Format: 11110000

The Enable Failsafe command enables the Failsafe mode. The internal time counters controlling the Failsafe duty cycle are started but not reset. Figure 1 displays the message format when the ST-13 is in the Failsafe mode. The first word following the Failsafe ID code is always the "Error Counts" followed by the 4 most recent error codes.

7.0 Ground Station Interface

The ARGOS System is an ASCII e-mail based system. The data will delivered in the format described in Chapter 4 of the ARGOS User Manual. Below is the data received via e-mail from ST-13 ID 9344 and the code segment that produced it.

```
00679 09344 41 32 J
2000-03-06 19:18:51 1 97 98 99 100
101 102 103 104
105 106 107 108
109 110 111 112
113 114 115 116
117 118 119 120
121 122 97 98
99 100 101 102
2000-03-06 19:21:51 1 97 98 99 100
101 102 103 104
105 106 107 108
109 110 111 112
113 114 115 116
117 118 119 120
121 122 97 98
99 100 101 66
2000-03-06 19:22:51 1 97 98 99 100
101 102 103 104
105 106 107 108
109 110 111 112
113 114 115 116
```

117 118 119 120
121 122 97 98
99 100 101 102
2000-03-06 19:23:51 1 97 98 99 100
101 102 103 104
105 106 107 108
109 110 111 112
113 114 115 116
117 118 119 120
121 122 179 102
201 178 108 217
2000-03-06 19:28:51 4 97 98 99 100
101 102 103 104
105 106 107 108
109 110 111 112
113 114 115 116
117 118 119 120
121 122 97 98
99 100 101 102

```
int main (void)
{
      int xmit_status, rcv_status ; // Status of transmit buffer
      unsigned char response,response1,response2;//response from Argos

      // Set up number of data and stop bits, plus parity - 8 N 1

      // Load up the data array to send to Argos

      // Binary string used for reading stack and sending data to Argos
      unsigned char data_array[35] = {0x61,
0x62,0x63,0x64,0x65,0x66,0x67,
                        0x68,0x69,0x6A,0x6B,0x6C,0x6D,0x6E,
                        0x6F,0x70,0x71,0x72,0x73,0x74,0x75,
                        0x76,0x77,0x78,0x79,0x7A,0x61,0x62,
                        0x63,0x64,0x65,0x66,0X67,0x68} ;

      //************************************************************

      do
      {
            gettime(&time_of_day) ;

            //*****************************************************
            //  Now sit and wait for a new minute
            if(old_minutes == new_minutes)
            {
                  gettime(&time_of_day) ;
                              }
            else
            {
                  // Send a wakeup call to the Argos 50 milliseconds
```

```
            xmit_status = inportb(COM3_LSR) ;
            while((xmit_status & 0x40) == 1)
                  xmit_status = inportb(COM3_LSR) ;
            outportb(COM3_MCR, 0x02) ;

            delay(75) ;

            xmit_status = inportb(COM3_LSR) ;
            while((xmit_status & 0x40) == 1)
                  xmit_status = inportb(COM3_LSR) ;
            outportb(COM3_MCR, 0x00) ;

            delay(25) ;

//************************************************************
            // Send command to Store1
            xmit_status = inportb(COM3_LSR) ;
            while((xmit_status & 0x40) == 1)
                  xmit_status = inportb(COM3_LSR) ;
            outportb(COM3, 0x10) ;

            delay(6) ;

            // Sends 32 bytes of data to Argos - binary
            for(i=0; i<=33; i++)
            {
                  outportb(COM3, data_array[i]) ;

                  delay(6) ;
            }

            // Wait for data ready or timeout
      if(Timeout==FALSE)//Get response from Argos-Ack or Nack
                  response1 = inportb(COM3) ;

//************************************************************

            // Send command to Transmit
            xmit_status = inportb(COM3_LSR) ;
            while((xmit_status & 0x40) == 1)
                  xmit_status = inportb(COM3_LSR) ;
            outportb(COM3, 0x50) ;

            // Timer variables for timeout reading stack

            // Wait for data ready or timeout
            rcv_status = inportb(COM3_LSR) ;
            while(((rcv_status & 0x01) != 1)& (Timeout == FALSE))


            if(Timeout == FALSE)
                  response = inportb(COM3) ;
```

8.0 Document References

8.1 General

This section lists the standards, specifications, and other documents which serve as a reference for supplemental system and subsystem descriptive information. Other documents listed are directly applicable to this ICD and may by specific references constitute a part of this ICD.

8.2 Specifications

- ULDB Flight Software Requirements and Functional Specifications, Ver. 1.11
- ULDB Design to Requirements Document (DTRD), 820-ULDB-DTRD-002.1
- ULDB Control Center Requirements and Functional Specifications, Ver. 2.2

8.3 Standards & Other Documents

- Electrical Characteristics of Balanced Voltage Digital Interface Circuits, EIA RS-422A (Federal Standard 1020A), Electronic Industries Association, Washington, D.C.
- User Manual for the Telonics ST-13 Asynchronous Serial Interface, PB005443, 08/04/1997
- ARGOS USER MANUAL 1.0 January 1996